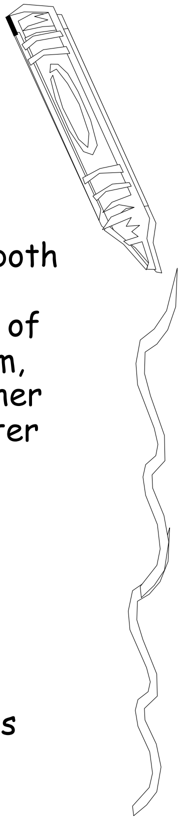
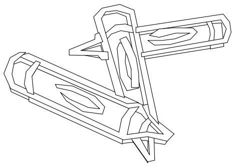


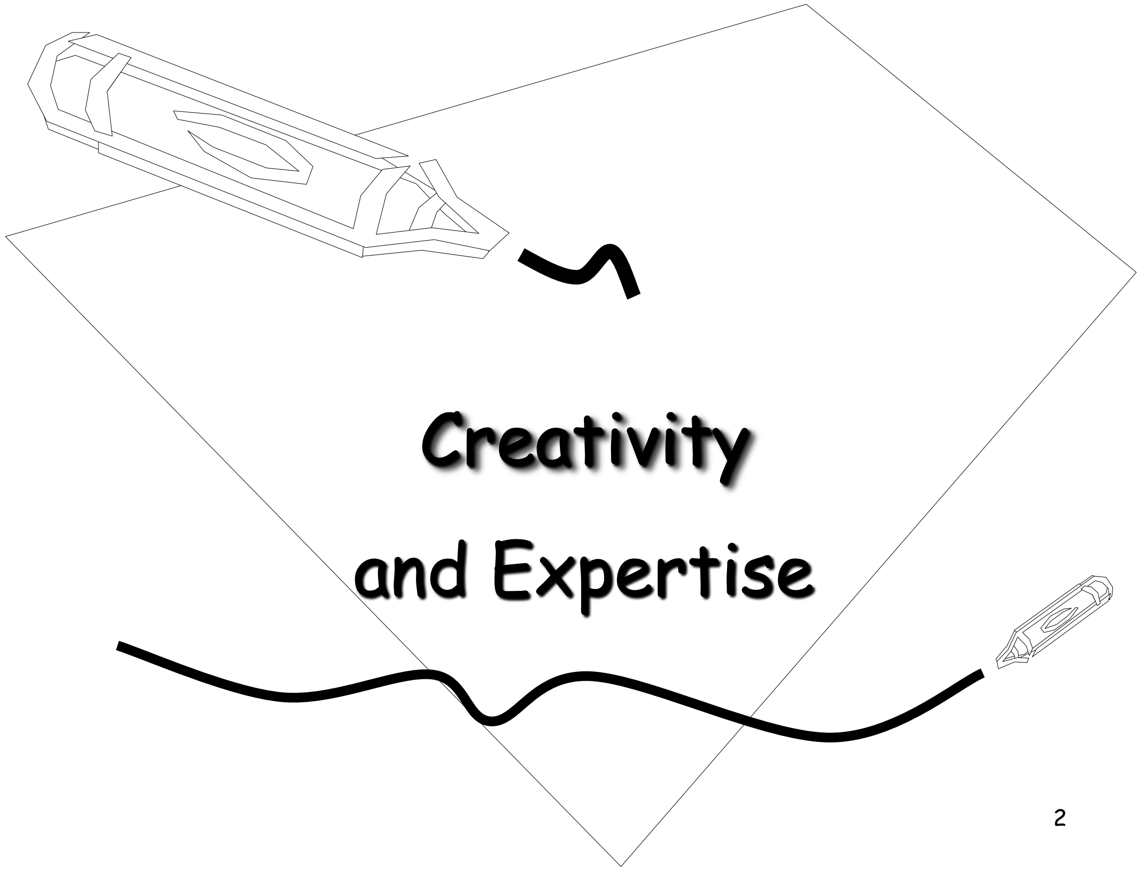
Thought Question

An experimenter asks two groups of subjects to solve both the Missionary and Cannibals problem and the tumor problem. Each group works on each problem for a total of 30 minutes. Group 1 works continuously on each problem, while Group 2 takes a fifteen minute break (doing another task) in the middle of working on each. The experimenter obtains the following results:

	M&C	Tumor
Group 1	80%	10%
Group 2	77%	50%



What might we conclude from these results about incubation and problem solving?



Creativity and Expertise

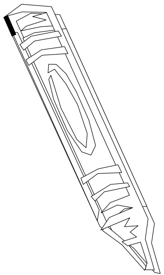
What is creativity?

A creative solution
to a problem is one
that is both
relevant
and
original.

Divergent Thinking

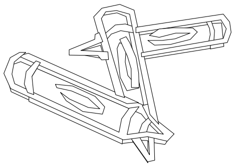
Tests of creativity in psychology often look at divergent thinking.

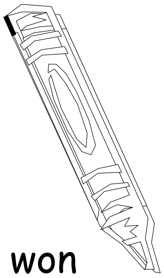
- convergent thinking: focusing in on a single solution (logical/analytical)
- divergent thinking: expanding outward in many different directions



Example problems

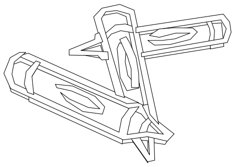
- Two men played five games of checkers. Each won three games. How can this be?
- Add one line to IX to make six.
- A farmer ate two eggs for breakfast every morning. He had no chickens; nobody ever gave him any eggs; and he never bought, borrowed, begged, or stole any eggs. Where did he get the eggs?

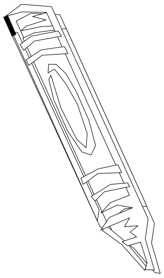




Answers

- Two men played five games of checkers. Each won three games. How can this be?
    - They played different opponents.
- Add one line to IX to make six.
    - Add the curved line “S” in front of IX.
- A farmer ate two eggs for breakfast every morning. He had no chickens; nobody ever gave him any eggs; and he never bought, borrowed, begged, or stole any eggs. Where did he get the eggs?
    - He had a duck.

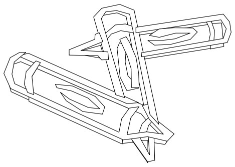


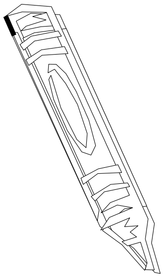


How to study creativity?

- One approach: look at how geniuses (artistic, musical, scientific) came up with their most creative works

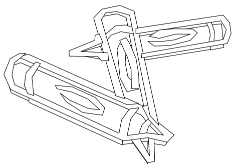
- Problem: relies on introspection
- Answer often “it just came to me . . .”

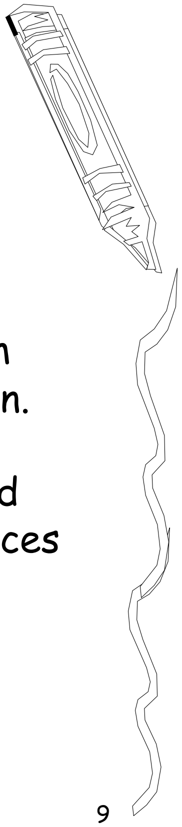




Traditional View

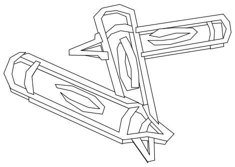
- Wallas (1926)
- Stages of a creative idea:
  - preparation: study area, set up problem
  - incubation: put problem aside
  - illumination: achieve (sudden?) insight
  - verification: make sure solution works

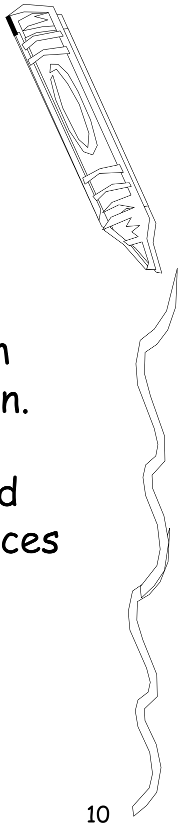




Illumination

- “Sudden” appreciation of solution.
- Example: A stranger approached a museum curator and offered him an ancient bronze coin. The coin had an authentic appearance and was marked with the date 544 B.C. The curator had happily made acquisitions from suspicious sources before, but this time he promptly called the police and had the stranger arrested. Why?





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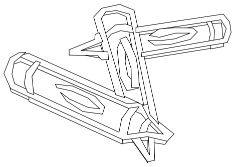
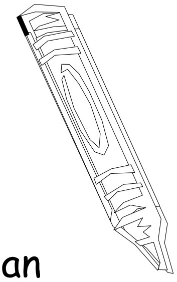
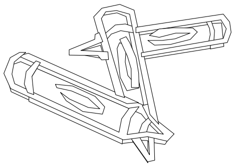
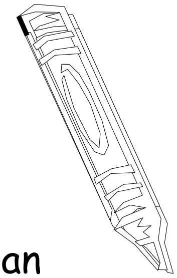




Another Example

A barn is completely empty except for a dead man hanging from the middle of the central rafter. The rope around his neck is 10 feet long and his feet are three feet off the ground. The nearest wall is 20 feet away from the man. It is not possible to climb up the walls or along the rafters. The man hanged himself. How did he do it?





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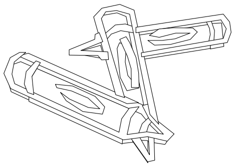
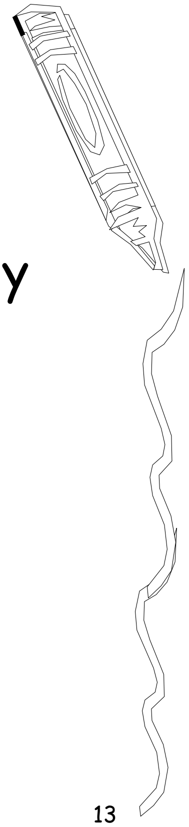
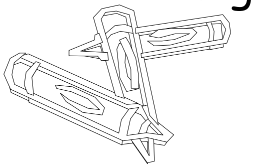
He stood on a block of ice, which has since melted and evaporated.

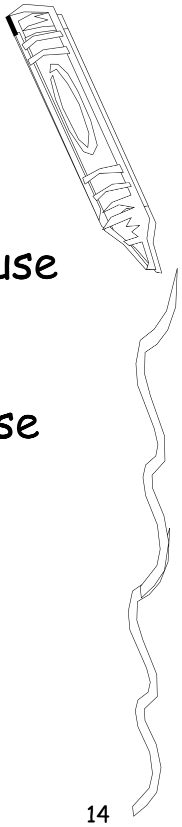




Illumination

- What causes illumination? And why might incubation help?
- Get rid of wrong approaches?
  - functional fixedness and set effects
  - release from retrieval blocking
- Find new approaches?
  - right hemisphere contributions

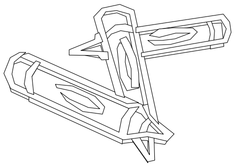


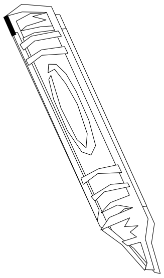


Release from blocking

- Retrieval of related information can cause blocking for desired information.

- Incubation may allow activation for these competing memories to fade, so can try again.

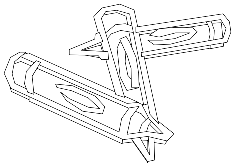


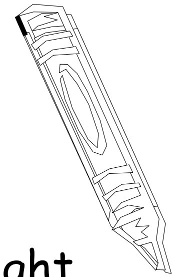


Release from blocking

Can test experimentally.

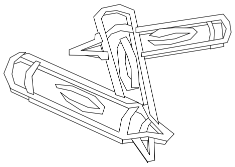
- Four groups trying to solve a problem.
- Two groups get misleading information, while control groups do not.
- One group of controls and one "misled" group get incubation time; others do not.
- Incubation doesn't help controls much but is a big help to group with misleading information.





The Right Hemisphere

- Controversial, but common, view that right hemisphere is important for creativity.
  - Left: analytical and logical
  - Right: creative and artistic
- Certainly not true in strongest form. But aspects may be correct.



Why insight is different

Some interesting differences between insight and non-insight problem solving.

- importance of incubation
- role of language
- sense of progress

Language and problem solving

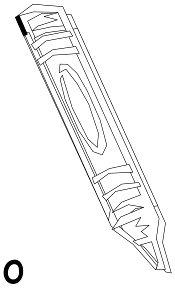
- Giving a verbal protocol seems beneficial for non-insight problems.
  - makes people aware of their strategies
  - better metacognitive understanding
  - can lead to higher solution rates
- However, talking seems to interfere with solving insight problems. WHY?

Sense of progress

- With insight problems, people often experience little sense of progress.
  - – suggests involvement of unconscious processes
    - relaxation of constraints
    - representational change
- One hypothesis: unconscious processing happens in the right hemisphere, which is better at some types of problems.

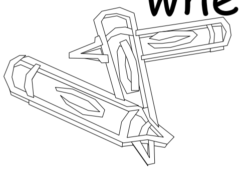
Hemispheric Differences

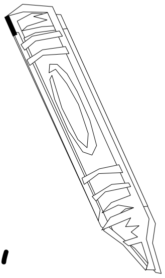
- Recall that left hemisphere seems to “have control of” language and consciousness.
- If right hemisphere solves a problem when left hemisphere cannot, need to somehow get information to left in order to be aware of it and talk about it.



Hemispheric Differences

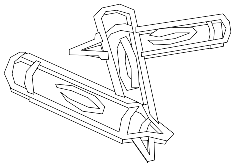
- Incubation: distract left hemisphere so right can temporarily gain control.
- Silence: allows more resources to go to non-linguistic right hemisphere.
- No Sense of Progress: less in tune with right hemisphere processing.
- A-HA! Left hemisphere’s feeling when the right “tells” it the answer.

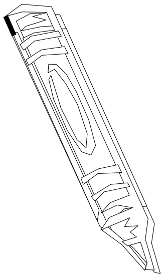




Interim Summary

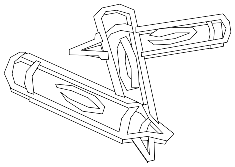
- Creativity linked with “illumination”.
- But not very satisfying cognitive theory: “you [somehow] figure it out”
- Some attempt to understand process
  - response perseveration
  - blocking
  - hemispheric differences

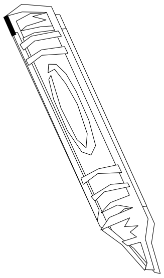




How else to study creativity?

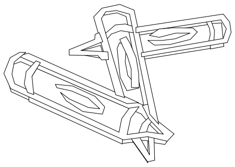
- Measure creativity.
- Try to correlate with behavior in the laboratory.
- How do individuals who score high on tests of creativity differ from those who score less high?

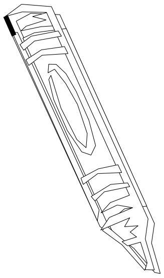




Laboratory tests

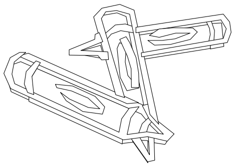
- Remote associates test (RAT)
- What word is associated with all three of these words:
  - (1) brick, out, boat
  - (2) ache, sweet, burn
- Answers:
  - (1) house
  - (2) heart

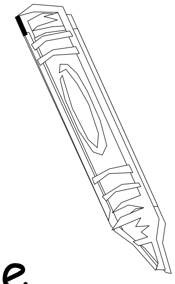




Laboratory tests

- Unusual uses test
- Name as many things as you can that you can do with paper cups.
- Score based on
  - fluency: number in a certain time
  - flexibility: number of classes of solutions
  - originality: number of solutions that are not given by many other people

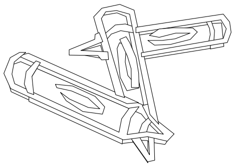




Creative People

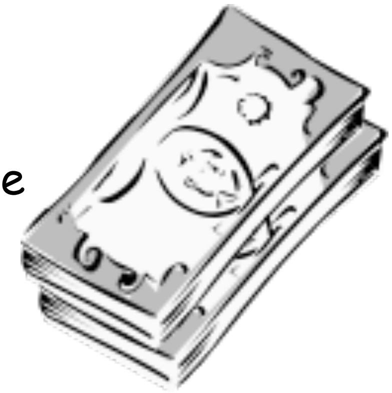
What are characteristics of creative people?

- intrinsic motivation
- working on task because you find it interesting, exciting, challenging
- NOT for reward (material or social)



Creative People

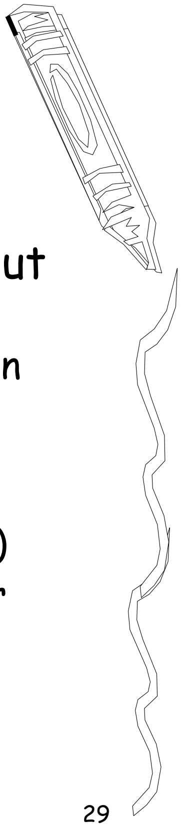
- In fact, extrinsic motivation seems to reduce creativity.
  - people are less creative when they know their work will be judged
  - even when reward is FOR creativity!



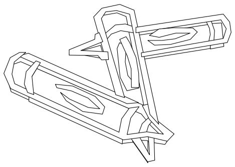
Labor of love

- Why is intrinsic motivation good?
- Maybe mood?
- Studies show better performance on the RAT when in a good mood.
- My own work found more “creative” sentence processing with positive mood.

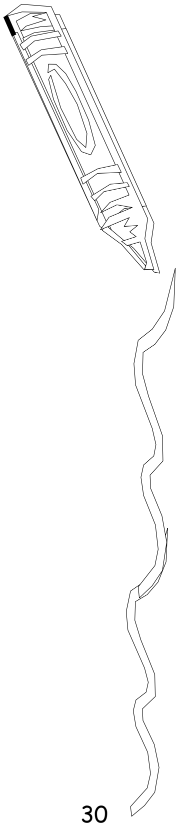
Labor of love



- In turn, then must ask what is good about positive mood.
  - different chemical distributions in the brain (changes how brain functions)
  - different balance of the hemispheres (right and left hemisphere differentially associated with positive and negative mood)
  - Still don't know, but provides directions for exploration.

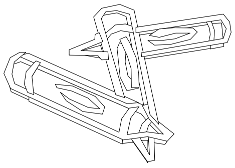


Creative People



Other characteristics:

- more able to see underlying problem (less influenced by framing)
- more patient; willing to delay a decision
- more self-critical
- work very hard
- have extensive knowledge base



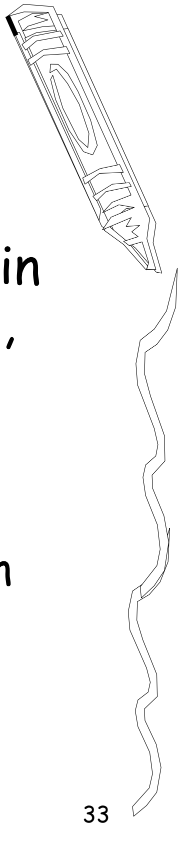
Knowledge

A richer, more detailed knowledge base allows a broader search for solutions.

- more analogies to consider
- better understanding of the structure within possible source domains.

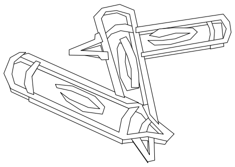
Interim Summary II

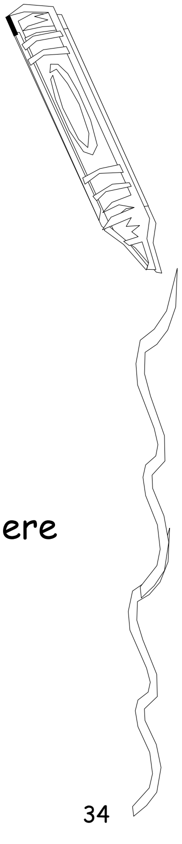
- Being creative is hard work!
- Motivation and knowledge very important.
- Developing knowledge base takes time.
- Need to work long enough for creative solutions to emerge.
- Creative people are (often) also experts.



What is an expert?

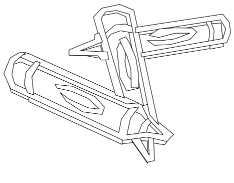
- Someone good at solving problems in a particular domain (chess, physics, auto repair).
- Experts have:
  - more knowledge
  - better/richer knowledge organization
  - more experience applying knowledge





Studying expertise

- One well-studied domain is chess.
- Advantages of chess:
  - well-defined problem
  - many possible moves
    - after just three moves by each player, there are > 9 million possible moves!
  - well-defined goal
  - good means of assessing expertise



How to study?

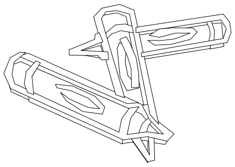
- Observe experts at work.
- In laboratory, compare experts and novices.
  - how well does each perform on various tasks?
  - what do they do differently?

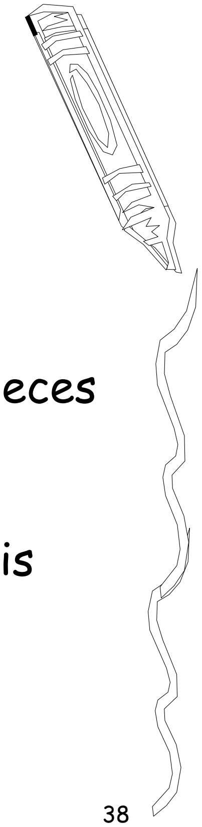
Chess experts

- DeGroot (1946) compared chess players of varying ability.
- Better chess players select better moves
  - don’t seem to consider MORE moves (typically around four “next moves” and thirty total)
  - compare with computer programs that search 90 billion moves each turn!
  - but moves they consider are much better ones

Better moves

- Why do experts consider better moves?
- Better memory?
- TEST: Briefly show experts and novices an arrangement of chess pieces on the board. Ask them to recreate the board after a delay.

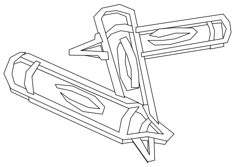




Better moves

RESULTS:

- If arrangement comes from an actual game, experts remember many more pieces and positions than novices.
- But if pieces are arranged randomly, experts’ memory for the arrangement is the same as novices’.



Better moves

- General memory about the same.
- Experts have chunks for meaningful arrangements of pieces.
  - put out **groups** of pieces when recreating arrangement
  - talk about arrangements as units (kind of opening, kind of end game arrangement, memory of specific game)
  - estimated to have about 50,000 patterns

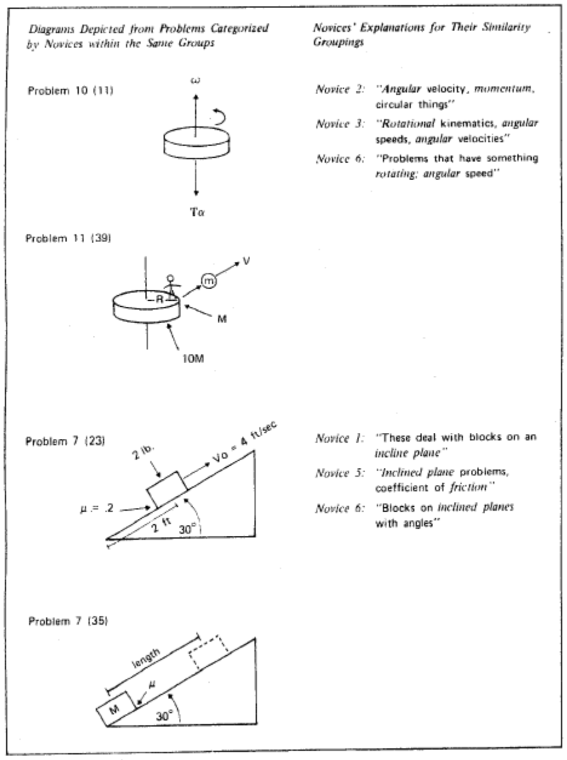
Better moves

- Having chunks helps memory.
- Better memory means fewer errors.
- And more time to develop a strategy.

- Kind of like learning to read.

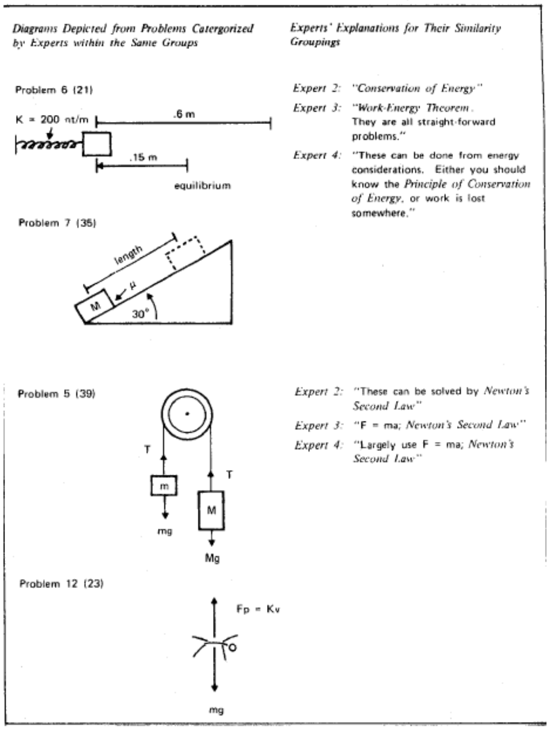
Better representations

- More generally, experts seem to use better representations of problems.
- Experts and novices asked to group physics problems.
  - novices grouped by surface features
    - these contain pulleys, these angled blocks
  - experts group by structural features
    - force problems, momentum problems



Diagrams Depicted from Problems Categorized by Novices within the Same Groups	*Novices' Explanations for Their Similarity Groupings*
Problem 10 (11)	*Novice 2:* "*Angular* velocity, *momentum*, circular things" *Novice 3:* "*Rotational* kinematics, *angular* speeds, *angular* velocities" *Novice 6:* "Problems that have something *rotating; angular* speed"
Problem 11 (39)	
Problem 7 (23)	*Novice 1:* "These deal with blocks on an *incline plane*" *Novice 5:* "*Inclined plane* problems, coefficient of *friction*" *Novice 6:* "Blocks on *inclined planes* with angles"
Problem 7 (35)	

Figure 1. Diagrams depicted from two pairs of problems categorized by novices as similar and samples of three novices' explanations for their similarity are provided. Problem numbers given represent chapter, followed by problem number from Halliday and Resnick (1974).


Problem 6 (21)
K = 200 nt/m
.6 m
.15 m
equilibrium
Problem 7 (35)
length
M
μ
30°
Problem 5 (39)
T
m
mg
T
M
Mg
Problem 12 (23)
Fp = Kv
mg

Diagrams Depicted from Problems Catergorized by Experts within the Same Groups

Experts' Explanations for Their Similarity Groupings

Expert 2: "*Conservation of Energy*"

Expert 3: "*Work-Energy Theorem*. They are all straight-forward problems."

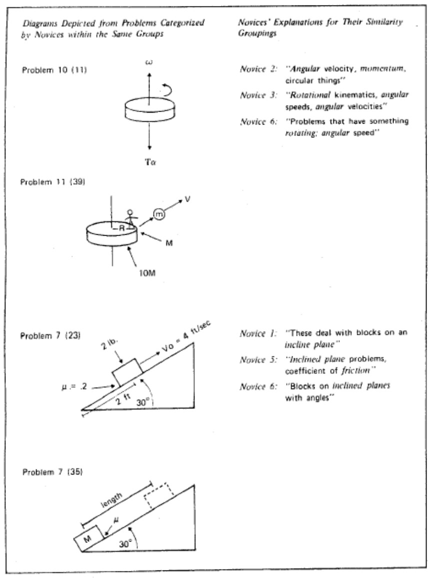
Expert 4: "These can be done from energy considerations. Either you should know the *Principle of Conservation of Energy*, or work is lost somewhere."

Expert 2: "These can be solved by *Newton's Second Law*"

Expert 3: "F = ma; *Newton's Second Law*"

Expert 4: "Largely use F = ma; *Newton's Second Law*"

Figure 2. Diagrams depicted from pairs of problems categorized by experts as similar and samples of three experts' explanations for their similarity are provided. Problem numbers given represent chapter, followed by problem number from Halliday and Resnick (1974).


Problem 10 (11)
ω
Tα
Problem 11 (39)
V
m
R
M
10M
Problem 7 (23)
2 lb.
Vo = 4 ft/sec
μ = .2
2 ft
30°
Problem 7 (35)
length
M
μ
30°

Diagrams Depicted from Problems Categorized by Novices within the Same Groups

Novices' Explanations for Their Similarity Groupings

Novice 2: "*Angular* velocity, *momentum*, circular things"

Novice 3: "*Rotational* kinematics, *angular* speeds, *angular* velocities"

Novice 6: "Problems that have something *rotating; angular* speed"

Novice 1: "These deal with blocks on an *incline plane*"

Novice 5: "*Inclined plane* problems, coefficient of *friction*"

Novice 6: "Blocks on *inclined planes* with angles"

Figure 1. Diagrams depicted from two pairs of problems categorized by novices as similar and samples of three novices' explanations for their similarity are provided. Problem numbers given represent chapter, followed by problem number from Halliday and Resnick (1974).

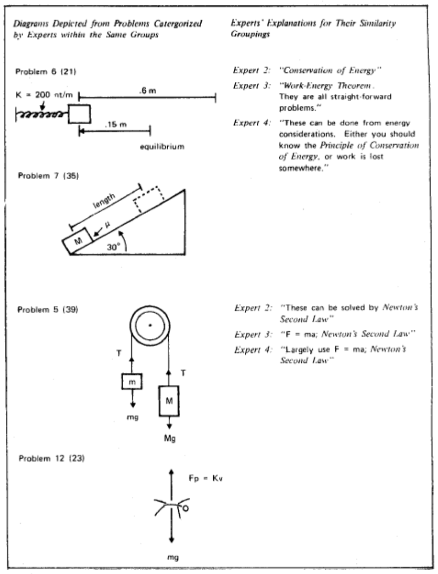

Diagrams Depicted from Problems Catergorized by Experts within the Same Groups

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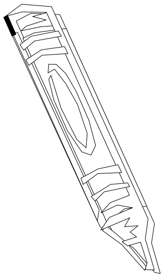
Figure 2. Diagrams depicted from pairs of problems categorized by experts as similar and samples of three experts' explanations for their similarity are provided. Problem numbers given represent chapter, followed by problem number from Halliday and Resnick (1974).

Better representations

- Experts have schemas.
- Schemas provide:
  - rapid categorization of problem type
  - structure for information
  - better inferences/elaboration

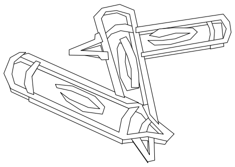
Better representations

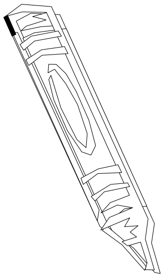
- Can see this in the process.
- Experts take longer to start -- spend more time setting up representation and searching for knowledge.
- But then experts often follow clear plan, from initial conditions to goal.
- Novices more likely to work backwards, search randomly.



Better metacognition

- Experts have better subjective understanding of their problem solving.
  - more accurate at judging problem difficulty
  - more aware of errors
  - more skilled at allocating time

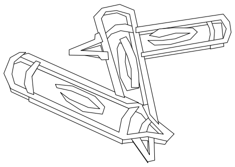


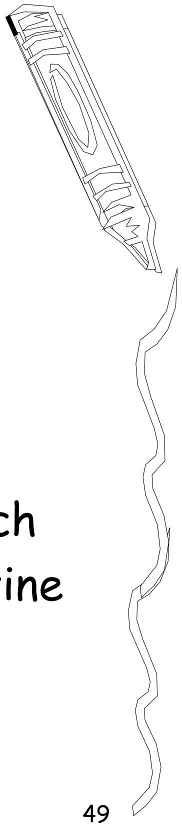


Interim Summary III

Experts have the same cognitive limitations as novices:

- working memory capacity is limited
- search through long term memory is hard
- can’t consider everything

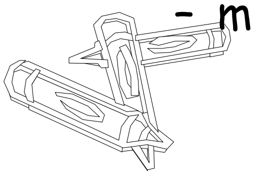




Overcoming limitations

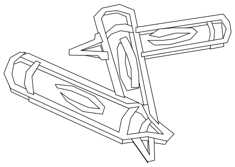
Experts overcome these limitations using strategies we have already discussed:

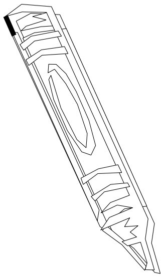
- chunking in working memory
- experience to guide knowledge search
- practice, to make some aspects routine (require less attention)
- monitoring with metacognition



Overcoming limitations

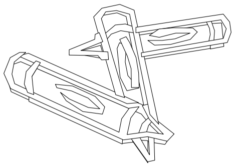
- So main difference between novices and experts may be immediate access to relevant knowledge.
- Building that knowledge base -- and procedures to use it -- takes practice and time.

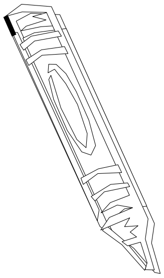




Expertise takes time

- Estimated to take ten years in most domains. Ten years of ACTIVE work!
- Expert violinists: more than 10,000 hours of practice by age 20
- Chess grand masters: about 30,000 hours
  - 10 hours a day, 6 days a week, for 10 years!
- Practice makes perfect!



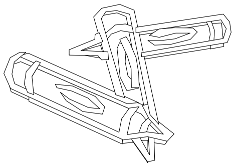


What's deliberate practice like?

- Involves delaying automaticity to refine performance

1) **Cognitive stage**—full attention to instructions, models, feedback
2) **Associative stage**—need cues, reminders for actions
3) **Autonomous stage**—motor programs using less attention; rapid and effortless; loss of the ability to verbalize process

- Not (usually) fun
  - "The requirement for *concentration* sets deliberate practice apart from both mindless, routine performance and playful engagement, as the latter two types of activities would, if anything, merely strengthen the current mediating cognitive mechanisms rather than modify them to allow increases in the level of performance."



Most people get just good enough

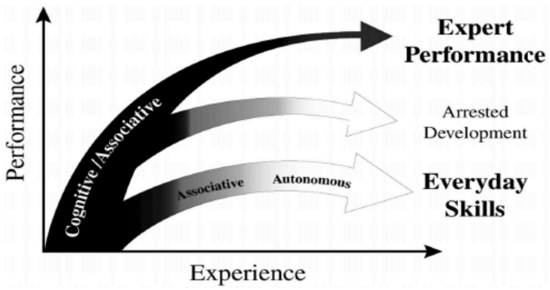
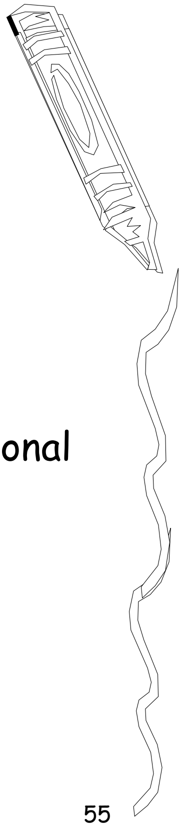


Figure 38.1. An illustration of the qualitative difference between the course of improvement of expert performance and of everyday activities. The goal for everyday activities is to reach as rapidly as possible a satisfactory level that is stable and "autonomous." After individuals pass through the "cognitive" and "associative" phases, they can generate their performance virtually automatically with a minimal amount of effort (see the gray/white plateau at the bottom of the graph). In contrast, expert performers counteract automaticity by developing increasingly complex mental representations to attain higher levels of control of their performance and will therefore remain within the "cognitive" and "associative" phases. Some experts will at some point in their career give up their commitment to seeking excellence and thus terminate regular engagement in deliberate practice to further improve performance, which results in premature automation of their performance. (Adapted from "The scientific study of expert levels of performance: General implications for optimal learning and creativity" by K. A. Ericsson in *High Ability Studies*, 9, p. 90. Copyright 1998 by European Council for High Ability.)

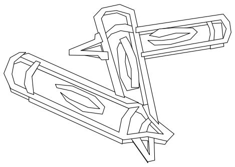
What about talent?

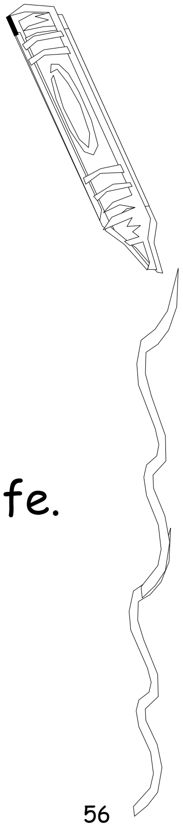
- Practice is great, but it isn't **just** about practice is it?
- Aren't some people just naturally good?
- TALENT: inherited predispositions that allow one to succeed in some domain



No talent?

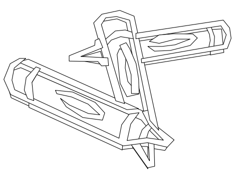
- Surprisingly, scientific evidence for influence of talent pretty weak.
- There are child prodigies. However:
  - most child prodigies do not become exceptional in domain as adults
  - most exceptional adults were not prodigies.

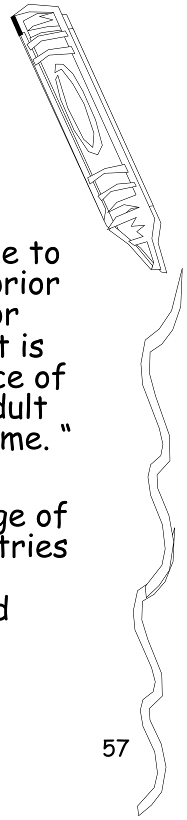




No talent?

- Some skills can be inherited.
  - perfect pitch
  - muscular composition
- But most of these can also be acquired with practice, especially when early in life.
  - perfect pitch can be trained before age 6
  - can change proportion of muscle types

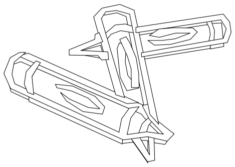


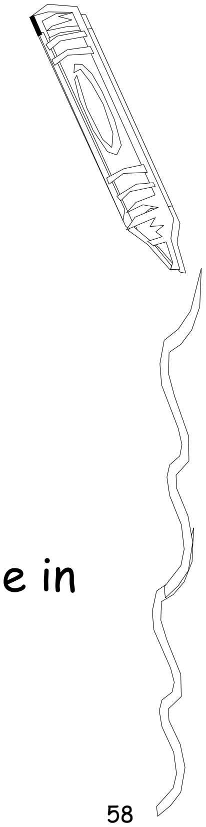


Practice (is the only thing that) makes perfect?

"There is no objective evidence that a child or adult is able to exhibit a high level of performance without any relevant prior experience and practice. Similarly, there is no evidence for abrupt improvements of reproducible performance when it is tested on a monthly or yearly basis. When the performance of child prodigies in music and chess are measured against adult standards, they show gradual, steady improvement over time. "

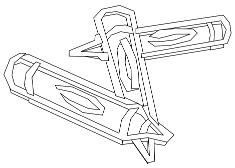
"Second, elite performance keeps improving beyond the age of physical maturation – the late teens in industrialized countries (Ulijaszek, Johnston, & Preece, 1998) – and is, thus, not directly limited by the functional capacity of the body and brain."

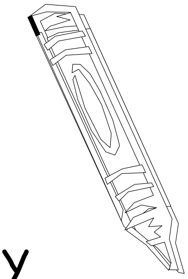




No talent?

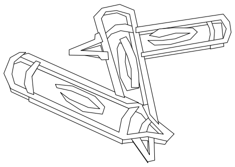
- Best determiner of performance still seems to be deliberate practice.
  - motivation
  - task difficulty "just out of reach"
  - corrective feedback
  - repetition
- Talent may predispose people to engage in practice in that domain.

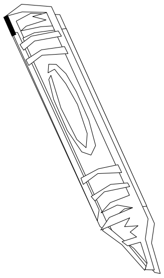




Summary

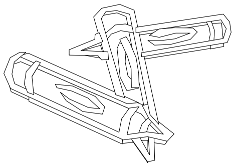
- Creativity and expertise build on MANY cognitive domains.
- Need to have:
  - knowledge
  - experience
  - motivation

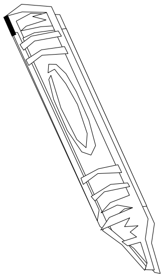




Summary

- Practice and time are important for:
  - effective allocation of attention
  - effective use of working memory
  - effective search for knowledge
  - effective application of knowledge to decisions
  - effective monitoring of performance





Summary

- We didn't have ten years in this class . . .
- (we all say "Thank goodness!")
- But hope the practice has been thought-provoking and enjoyable!
- And hope some of you will consider continuing down the road to expertise in this area.